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Hempelmann

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[54] **METHOD AND DEVICE FOR INCINERATING RADIOACTIVE WASTES AND PREPARING BURNABLE WASTES FOR NON-POLLUTING STORAGE**

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[52] **U.S. Cl.** ..... **110/8 R**; 55/313; 110/8 B; 110/101; 110/119; 110/165 R

[51] **Int. Cl.** **F23g 7/00**

[58] **Field of Search** ..... 110/8 R, 8 A, 8 B, 101, 110/119, 165 R; 55/313

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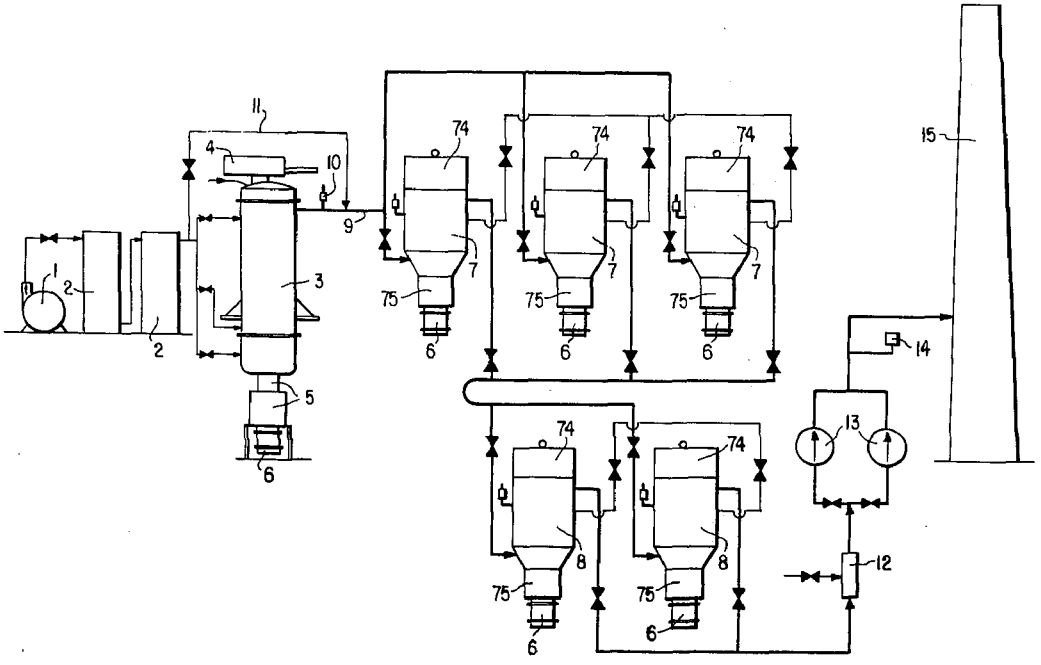
Primary Examiner—Kenneth W. Sprague
Attorney, Agent, or Firm—Spencer & Kaye

[57] **ABSTRACT**

An apparatus for incinerating radioactive wastes includes a furnace which has air inlet conduits and a flue gas outlet conduit and air heaters as well as blowers connected to the air inlets for forcing hot air into the furnace. The apparatus further has a feeding device connected to the charging end of the furnace for introducing liquid or solid wastes thereinto and a device which communicates with the discharge end of the furnace for removing solid reaction products from the furnace. In the flue gas conduit there is connected a plurality of flue gas filters each containing filter candles, a flue gas chamber and a mechanism for removing ashes from the flue gas chamber. The apparatus also includes a mixer section connected with the outlet of each flue gas filter and having a mechanism for mixing cool air with the flue gas filtered by the flue gas filters. Gas blowers connected to the output of the mixer section draw the gas from the apparatus.

18 Claims, 8 Drawing Figures



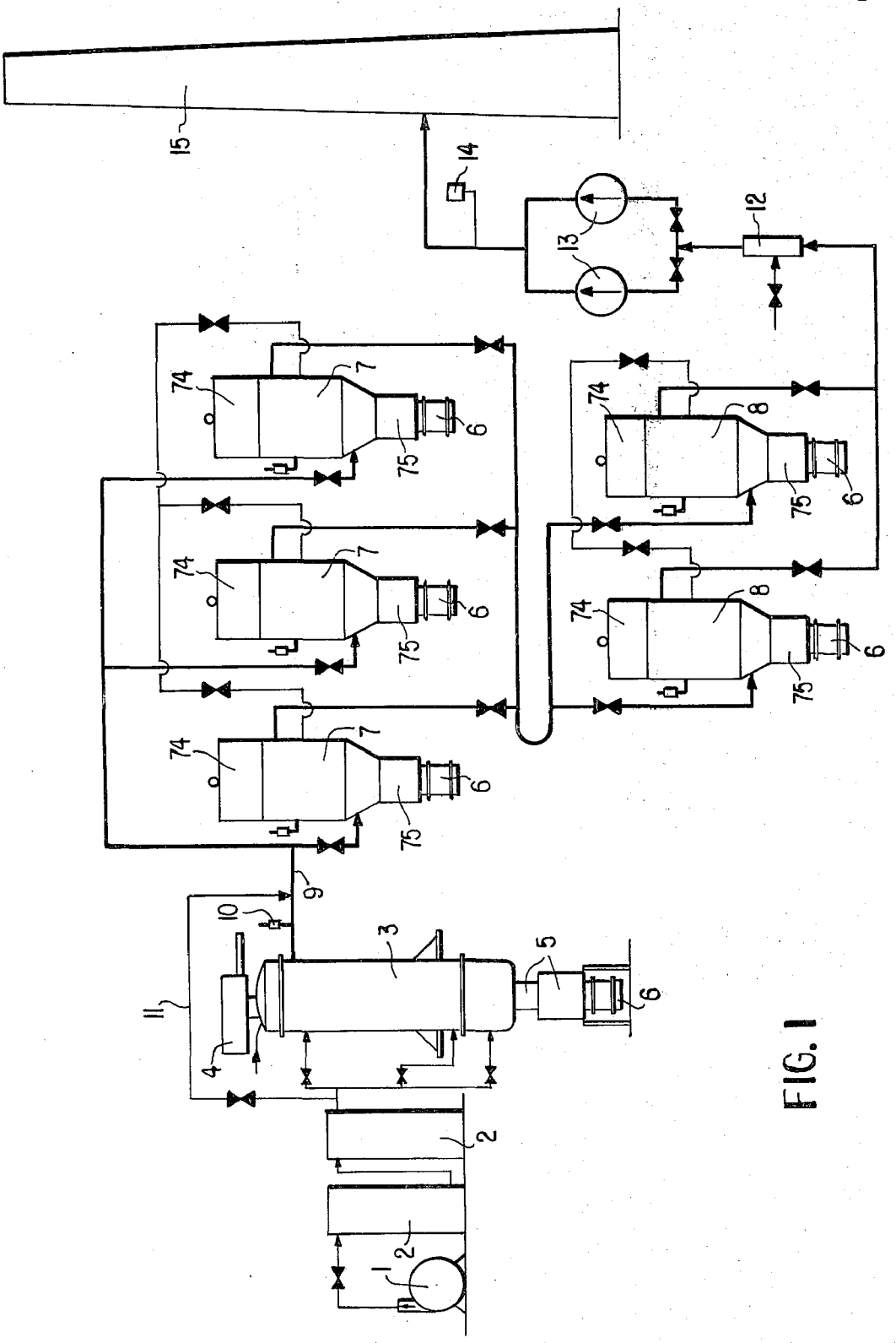


FIG. 1

FIG. 2

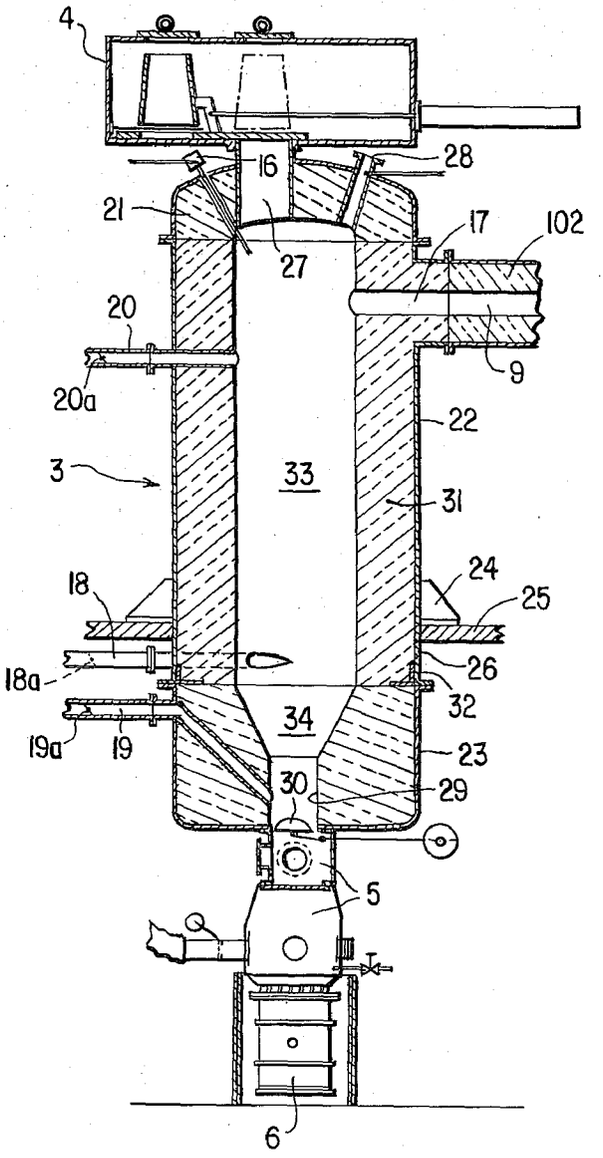

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FIG. 3

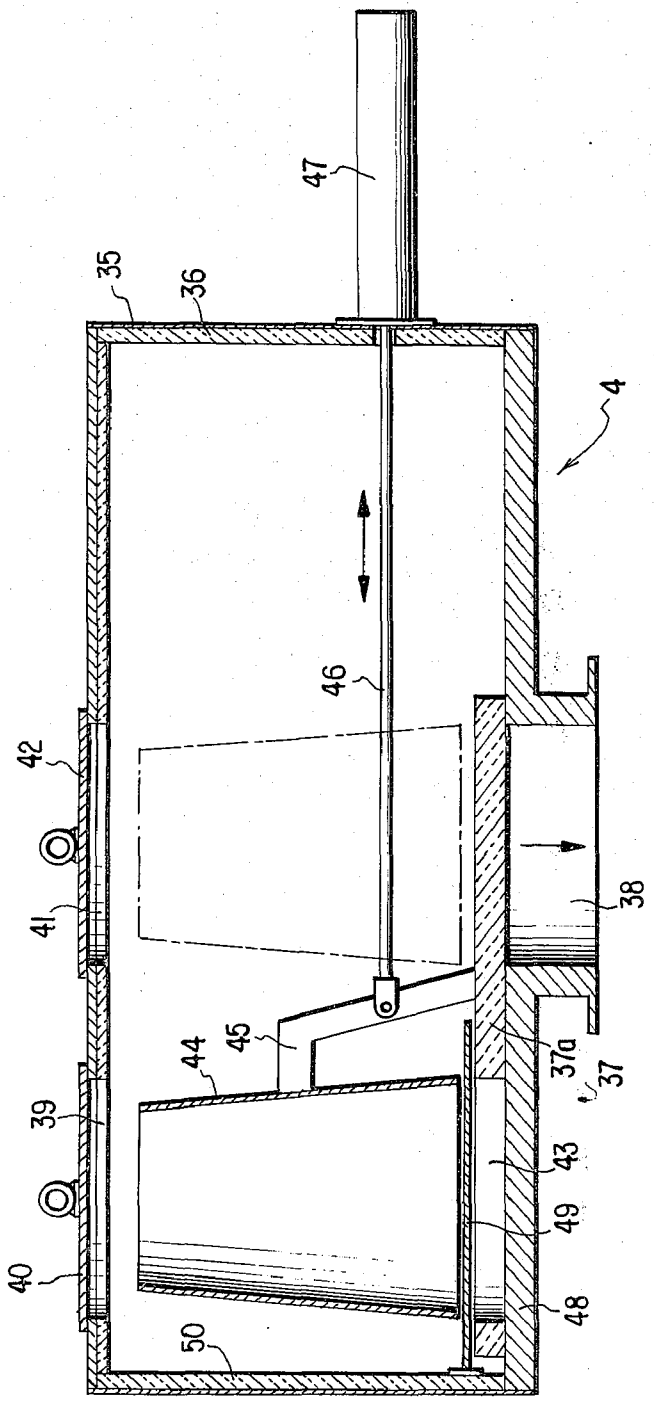


FIG. 4

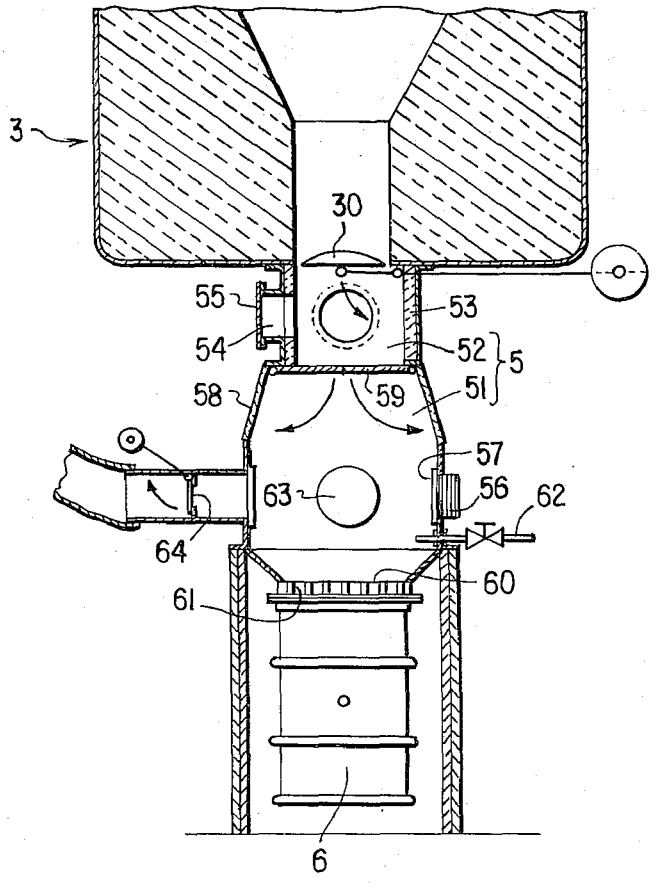
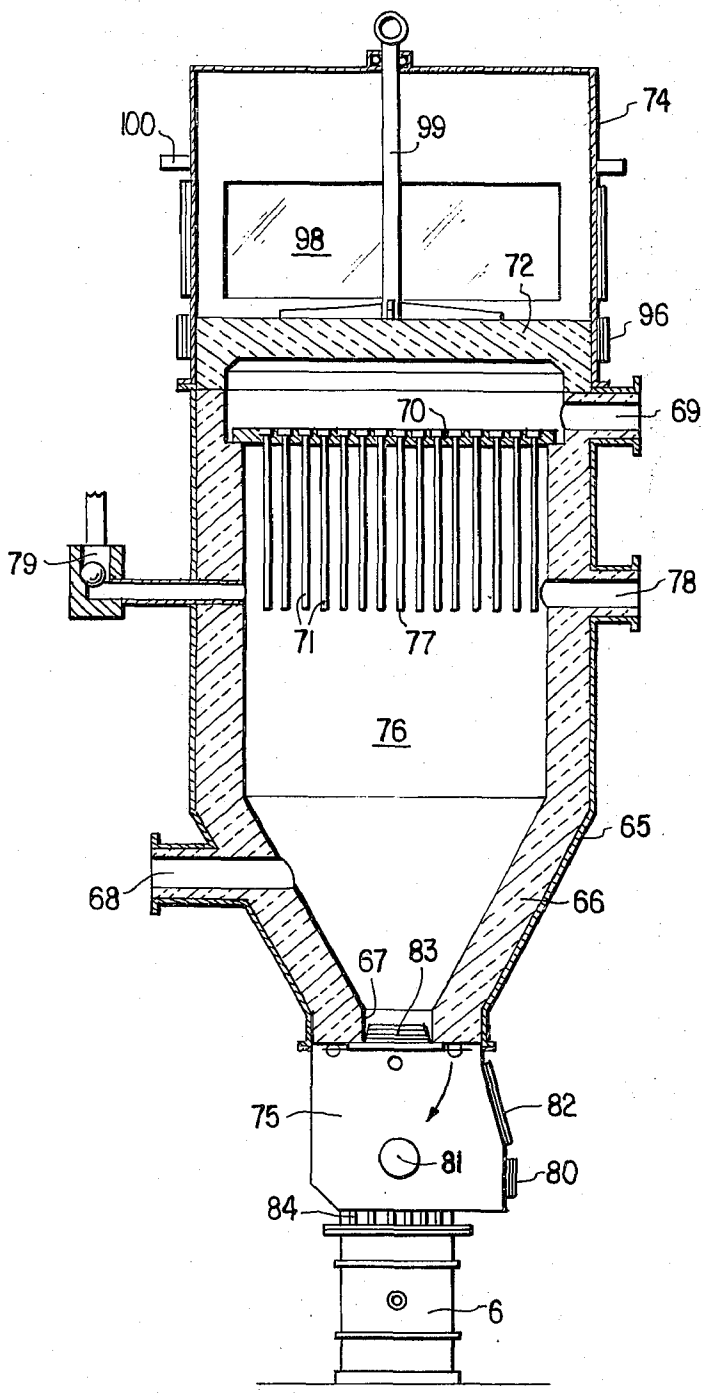


FIG. 5



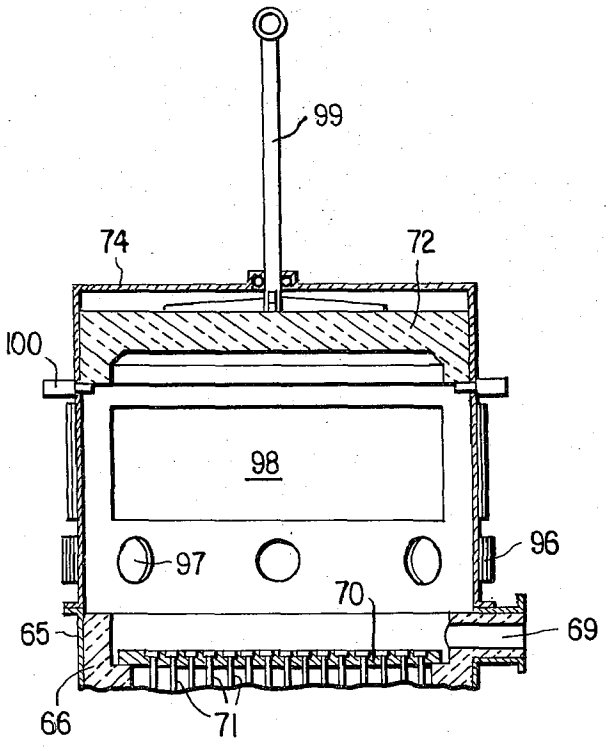


FIG. 5a

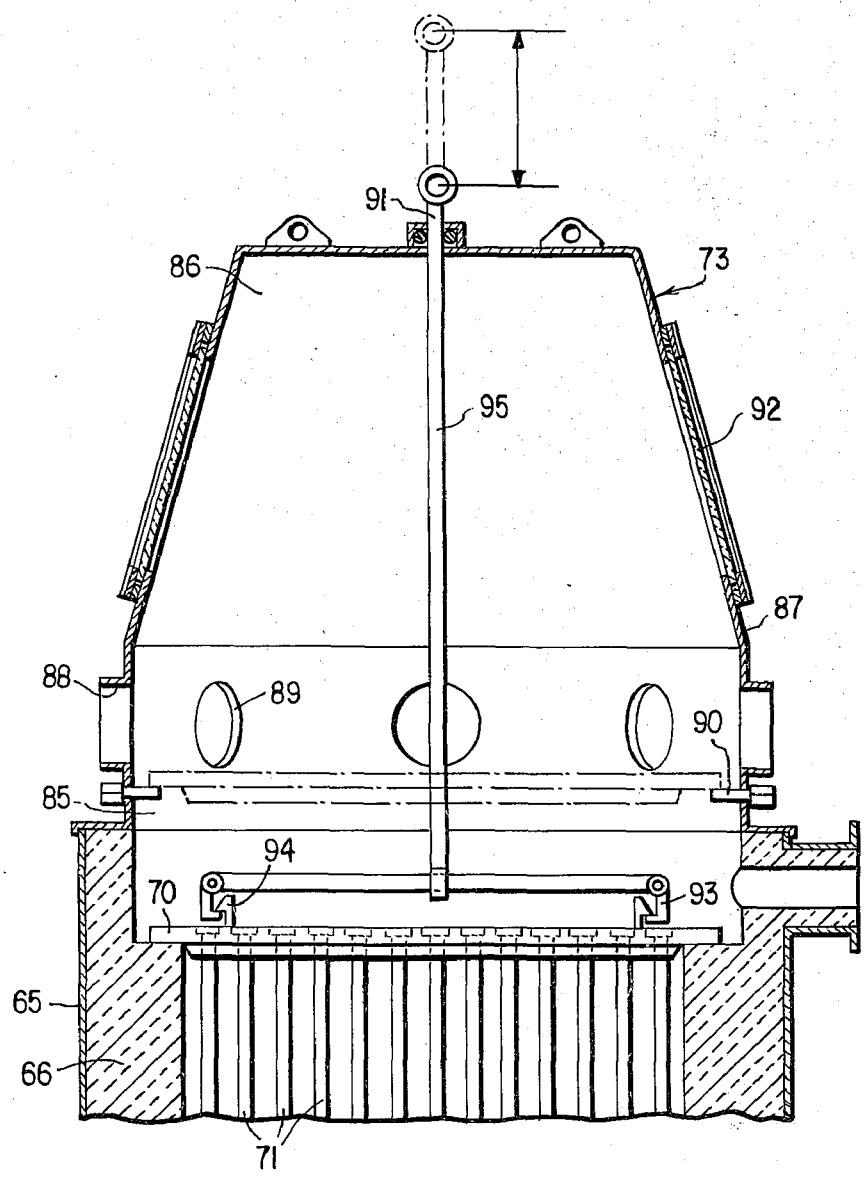
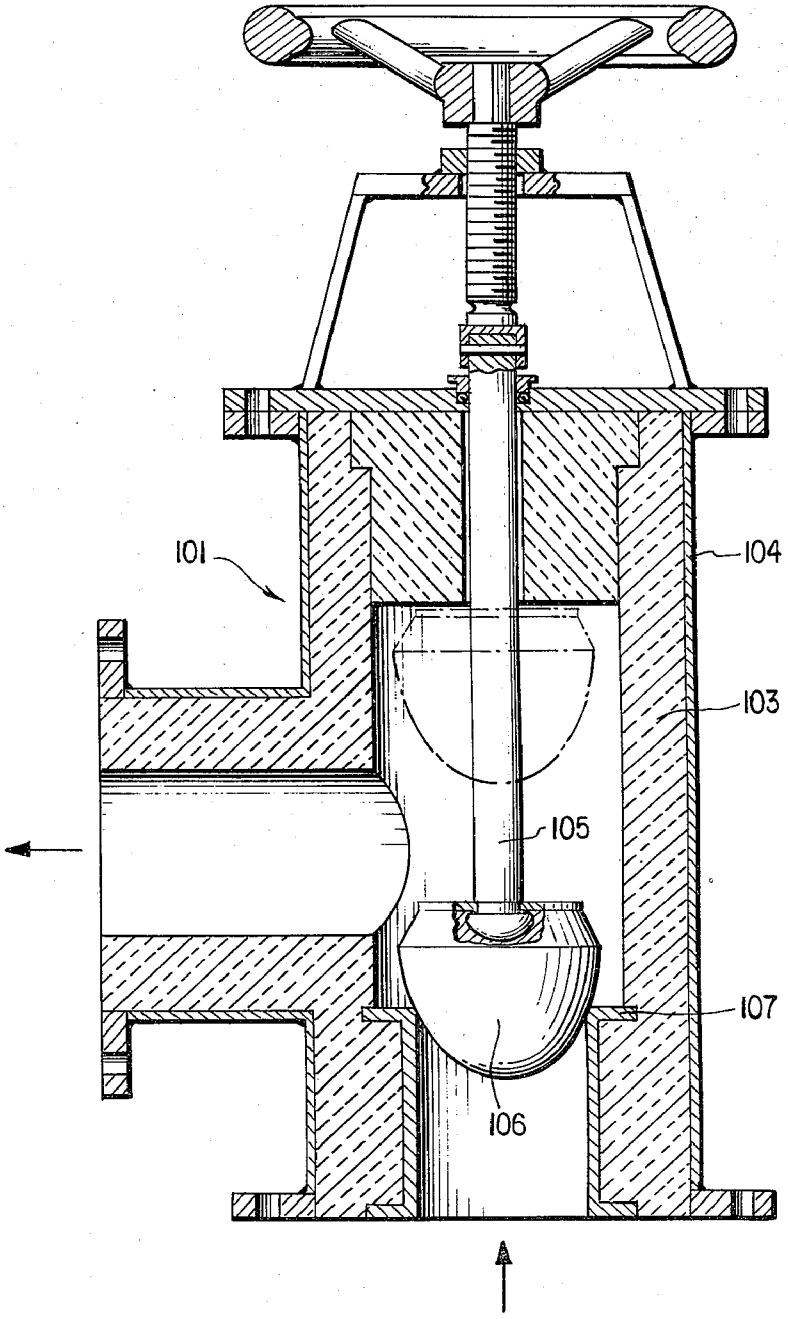


FIG. 6

FIG. 7



METHOD AND DEVICE FOR INCINERATING RADIOACTIVE WASTES AND PREPARING BURNABLE WASTES FOR NON-POLLUTING STORAGE

The present invention relates to a method and a device for incinerating radioactive wastes and preparing burnable radioactive wastes for non-polluting storage.

Methods and devices for incinerating radioactive burnable wastes have been described in the literature repeatedly. Incineration serves the purpose of minimizing the volumes of radioactive wastes and transforming them into a condition which positively excludes any digestion, fermentation or even fire during storage. However, incineration causes a number of problems, such as the very uniform, uninterrupted combustion of material whose composition changes continuously; the calorific value of burnable wastes varying between approximately 2,800 and 10,000 kcal/kg, or the positive prevention of any escape of radionuclides from the furnace, or the flue gases which may be very corrosive, depending on the type of waste.

Pregrading of burnable wastes, crushing and mixing such wastes could narrow down the range of calorific values causing these difficulties, but the capital cost and the additional space requirements connected with grading devices, a crusher, a mixer, and a silo with the respective feeding system are negative factors associated with such plants. Because of the high capital cost connected with incineration devices only plants with large throughputs (in excess of 50 kg/h) can be operated at an approximately economical level. Correspondingly, several incineration plants had to be closed down because of technical difficulties or uneconomical operation.

The incineration devices for radioactive wastes used so far are not based on a uniform design principle. Both combustion furnaces with and without auxiliary heaters can be found. The air supply to the furnaces is directed either from the top to the bottom or vice versa. Frequently, wet scrubbers are used to clean the flue gases. Incineration of wastes containing a high percentage of plastics generates very aggressive (corrosive) flue gases, which gives rise to condensates in the colder parts of the unit containing hydrochloric acid and tar.

An incineration device (pilot plant) for a throughput of approximately 30 kg/h consisting of an electrical air heater with air supply control, an incineration furnace bricked up in several layers with a rotary steel plate acting as the grate for removal of the ashes, and a simple sliding lock for feeding the waste into the furnace, a bricked-up flue gas line with valves, two parallel afterburning chambers (coarse filters), one fine filter with 49 ceramic filter candles installed in a cast iron plate, and a lid which can be removed if filter candles must be exchanged, a twostage water receiver acting as a tar separator, with a control system installed in a by-pass, and two rotary piston blowers, is described by W. Hempelmann and H. Krause in the periodical Chemie-Ingenieur-Technik, Volume 42, Issues 9 + 10 (1970), pages 645–653.

Disadvantages of this plant are the lack of economy resulting from the low throughput, the relatively large damage due to corrosion of metal parts occurring after relatively short periods of operation, the frequent cleaning and repair periods following upon relatively short operating periods, and the watchfulness high requirements on the alertness and qualification of the operating crew.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of incinerating radioactive wastes and preparing burnable radioactive wastes for non-polluting storage, which operates with a maximum of economy, i.e. which can be used to process any burnable waste generated in the solid or liquid state, practically without any preliminary treatment and without any grading, reducing it to the minimum possible volume in a safe and simple way and transforming it into a condition which is no longer burnable and thus fit for permanent storage. Another object of the present invention is to provide a device for the implementation of this method which can be operated with a minimum of energy, gives rise to practically no corrosion problems, can be operated also during replacement of filter candles, is relatively easy to repair and allows easy replacement of parts subject to wear and which further ensures a maximum of safety to the operating crew with respect to fire hazard and ionizing radiation during operation, and also during the replacement of filter candles and parts subject to wear as well as during the removal of ashes and solid incineration products and with respect to the discharge of flue gases, despite the accumulation of radionuclides in the furnace and in the filters as the period of operation increases. Moreover, the present device and parts thereof, respectively, will have prolonged service lives, i.e., the period of operation up to cleaning or replacement of parts subject to wear will be extended. On the one hand, the present device can be operated by personnel trained on the job, and, on the other hand, it will require only a minimum of personnel. It will be compact, requiring a minimum in terms of capital costs.

In the present invention this problem is solved in that wastes with low and high calorific values are combined and fed into an incineration furnace in such a way that the enery required for incineration, except the fraction needed for pre-heating in the start-up phase, is taken from the wastes proper, both solid and liquid wastes are fed into the furnace and burnt, the different increases in temperature of the flue gases generated during incineration as a consequence of different calorific values of the materials incinerated are limited by cooling only, and the solid reaction products are removed in containers so that they can be solidified and made into blocks fit for storage. In a further development of the present invention, the flue gases generated in the process of incineration are burnt completely and cleaned in a second combustion stage requiring only the energy contained in these flue gases, the temperature in the zone of the incineration reactions is kept in a range of approximately 1000°C to approximately 1200°C at a vacuum between 100 and 150 mm of water, and the temperature in the afterburning zone is in the range between approximately 800° and 900°C, whereas the temperature in the fine cleaning zone ranges between approximately 550°C and approximately 650°C.

A preferred embodiment of the device according to the present invention for the purpose of implementing the method is characterized by a tripartite furnace without a grate, with several air supply systems and a flue gas discharge system, a feeding device, a device for feeding liquids, and a device for the removal of solid reaction products, by several flue gas filters, which can

be operated alternately, connected with the flue gas discharge of the furnace by way of a flue gas line equipped with an explosion damper and containing devices for the replacement of filter candles, flue gas surge chambers and devices for the removal of ashes, and by several pure gas blowers connected parallel downstream of a mixer section for cooling air, and several air heaters connected upstream of the furnace and supplied with air by a forced draft blower.

In a further developement of the present invention the furnace consists of a cylindrical frame divided into three sections each of which is equipped with flanges, the top section together with the center section is arranged in a top chamber, the bottom section is arranged in a bottom chamber separate from the top chamber, the center chamber stands on brackets on a platform separating the top from the bottom chamber, its bottom section penetrating into the bottom chamber, the top and bottom sections are removable parts subject to wear, the top section is designed as a lid with a feed aperture connected with the feeding device. It further includes a device for feeding liquids, and an air cooled sight glass; the center section is equipped with two air inlet systems and a flue gas discharge system, the bottom section is connected with a device for the removal of solid reaction products by means of an aperture which can be locked and has a movable damper to close the aperture during incineration and release the entire cross section of the aperture while the solid reaction products are removed; in addition, there is an air inlet system directed at the damper; on the inside of the three sections of the frame the furnace contains a refractory ceramic lining consisting of several layers and closed on the inside, at least the outer layers of which lining in the center section rest on angular brackets of heat resistant steel attached to this center section. In a preferred embodiment, the air inlet systems in the bottom part of the center section and in the bottom section are arranged tangentially relative to the interior and in opposed directions relative to each other, whereas the air inlet system used for cooling purposes is arranged radially in the center section below the flue gas discharge. The interior of the center section is cylindrical, the interior of the bottom section initially tapers conically down to one third of the diameter, which part is followed by a uniformly cylindrical section.

In another embodiment of the device according to the present invention the feeding system is a double lock connected with the lid of the furnace so as to be removable and consists of a steel vessel whose inside is lined with an insulating material and which contains a slide damper movable in its interior, a bottom discharge which can be closed by the slide damper and is opened only while the furnace is loaded with solid wastes, a waste feed aperture which can be closed with a lid, and a maintenance aperture arranged over the bottom discharge and to be closed with a lid. The slide damper closing or uncovering the bottom discharge consists of a ceramic plate with an aperture of the same diameter as that of the bottom discharge, a pot installed above the aperture and expanding slightly concically towards the bottom with an angle plate connecting plate and pot, with a push rod connected to this angle plate and a compressed air cylinder. A steel plate is fitted with a small amount of clearance between the plate and the pot and rigidly connected to the wall of the feeding device to prevent wastes from sticking to the bottom of the feeding device. In a preferred embodiment of the present invention the device for removing solid reaction products consists of a glove box and an intermediate lock, through which the device for the removal of solid reaction products is connected to the furnace so as to be removable; the intermediate lock can be separated from the glove box, and it consists of a container with several sockets which can be closed by lids; the movable damper for closing the furnace is located in the container, one side of the container is so designed as to completely accommodate the opened damper while the solid reaction products are removed; the glove box contains several glove openings the inside of which can be closed by plugs; two windows are arranged opposite each other and there is a damper consisting of two parts, closing the glove box against the intermediate lock and movable downward in front of the windows to protect the windows during the removal of the solid reaction products; the bottom opening of the glove box is equipped with a coarse grating. The glove box for removal of the solid reaction products is equipped with a flushing connection, a lock for tools, and a large-area explosion damper.

In another embodiment of the present device, the flue gas filters consist of cylindrical steel frames covered with refractory ceramic linings and conically taper towards the bottom to one of the apertures used for the removal of ashes, they are equipped with one flue gas inlet each, one outlet each for the waste gas cleaned by afterburning and filtering, one inlet or outlet aperture each for the preheating gas required prior to startup of the respective flue gas filter, and one explosion damper each and each carries a plate made of steel or a ceramic material covered with a multitude of ceramic filter candles and has one bricked-up lid each; their upper ends are detachably connected to a device for filter candle replacement, and their bottom ends are detachably connected to a device for the removal of ashes. In a different embodiment of the present device, at least some of the flue gas filters have a square shape the bottom section of which tapers downward in the direction of an aperture for the removal of ashes. The flue gas inlet is installed at the upper end of the tapered part of the flue gas filter and the plate with the filter candle is installed at the upper end of the cylindrical or square part of the flue gas filter. The cylindrical or square interior of the flue gas filter between the flue gas inlet and the bottom ends of the vertically suspended filter candles, which can be exchanged in the plate and are fitted so as to be gastight, is designed as a flue gas surge chamber. The device for the removal of ashes is designed as a glove box (box for filter ashes). The box for filter ashes has several glove ports, at least one lock for the introduction of tools and at least one window and a swiveling damper closing and opening the aperture for the removal of ashes of the flue gas filter, respectively, and carries a coarse grating at the bottom end.

In a preferred development of the present invention, the device for replacing filter candles is designed as a removable glove box (removable box). The removable box consists of a housing the bottom part of which is fitted to the flue gas filter without a lid, the top part of which conically tapers upward and is equipped with several glove ports, at least one lock for the introduction of tools, and a locking device for arresting in the bottom part of the housing, the plate pulled into the removable box for replacing the filter candles, at least one window in the top part of the housing and a device which serves for lifting the plate and which penetrates

the housing in a gastight manner. The lifting device consists of a grip and a pull rod.

In another development of the present invention, the replacement device for filter candles is designed as a glove box (fixed box) arranged on top of the lid and attached to the steel frame. The fixed box has an inside diameter sufficiently large to allow the lid to be moved up and down inside the box and is equipped with several glove ports, at least one tool lock, at least one window and a pull rod connected to the cover and penetrating the wall of the fixed box in a gastight manner, and a device for arresting the cover pulled above the level of the window for replacement of the filter candles.

Upstream of the inlet and outlet openings of the flue gas filters the flue gas line is equipped with flue gas valves which are angle valves and which can be controlled manually and/or remotely. In a preferred embodiment of the present device, the flue gas line is equipped with several layers of a refractory lining, it contains tee-connections for control and cleaning purposes. Each of the angle valves consists of a T-shaped valve housing made of steel plate and covered with several layers of a refractory lining, a valve body spherically turned from round steel and attached to a valve rod so as to be movable, and a ring made of heat resistant steel as the valve seat arranged above the lining on the inlet side of the valve. The device used for feeding liquids consists of a double tube, an inner tube for feeding burnable liquids into the furnace and an outer tube for compressed-air feeding in order to atomize the liquid and cool the inner tube.

The method and the device, respectively, according to the present invention can be used to burn or incinerate wastes consisting mainly of, for instance, paper, wood, filter material, rubber gloves, overshoes, clothes, animal carcasses, ion exchange resins, organic solvents or plastics. Because practically all of the device is lined with ceramics, there will be no corrosion problems. All the incineration devices previously known either had major problems of corrosion or could not be used to burn specific types of waste, such as polyvinyl chloride (PVC). All these plants require additional burners, which increase the amount of flue gas produced and, hence, the required filter area. These disadvantages are avoided in the method and the device according to the present invention. The present device can be built to any size technically and economically required and desirable and can thus be adapted to any meaningful throughput of radioactive wastes.

The device contains only a small number of mechanically moved parts; it requires no water receiver as a tar separator, etc. Since the device is preheated prior to startup and coarse filters are used for afterburning via a by-pass line by means of air heaters, the plant can be started up with a minimum of wear and the flue gas filters can be operated uniformly and continuously, even if the coarse filter or the fine filter must be replaced, for instance, when filter candles are replaced. The fine filter is necessary to prevent radionuclides from escaping from the coarse filter into the waste gas line, especially if there is a defect in the coarse filter which has not yet been detected. Parallel connection of several coarse and fine filters, respectively, and preheating of the flue gas filters make the service life of a pair of filters practically unlimited. Hence, the service life of the present device is no longer a function of the service life of the flue gas filters and the filter candles, respectively, but only of the service life of the furnace and other components of the device.

The advantageous design of the feeding device, for instance the design as a removable double lock, or the design of the slide damper with a ceramic plate and a pot conically tapering downward, and the steel plate between the pot and the bottom of the device attached to the wall of the device reduce the heat dissipated from the furnace into the feeding device, prevent a potential, undesired release of radionuclides into the feeding device and practically exclude the possibility that wastes stick to the bottom of the device and adhere to the pot.

The subdivision into three sections of the frame of the furnace allows the lid and the bottom section, both of which are subject to wear, to be removed after separation of the closed ceramic lining. This is particularly important for replacement and repair of the bottom section of the furnace because this work can be performed in a room separate from the other components of the furnace, which greatly reduces the contamination hazard and radiation exposure of the personnel which might be due to the radioactively highly contaminated lining of the center section.

If the flue gas filters are strongly alpha-contaminated, the fixed box is advantageous in replacing filter candles because it allows their replacement without any hazard of contaminating the environment. The removable box, on the other hand, allows all the filter candles in a number of flue gas filters to be replaced one after the other by means of one box only. Moreover, removal of the lid of the flue gas filter can reduce the cooling time of the filter. Because of the greater hazard of contamination the removable box can be used only with β-and γ-contaminated filters.

Square flue gas filters can be set up in a space saving, compact arrangement with relatively short flue gas lines. Because of their rectangular base, the respective devices for replacing filter candles offer advantages of shape with respect to the manipulations to be carried out, provided that the dimension are fixed appropriately.

The special design of the flue gas valves ensures circular sealing of the edges, i.e. proper seating of the body of the valve on the steel ring, even if the valve body is polluted or scaled. In the case of scale formation the valve will be adjusted automatically when closing. While in operation, the closed valve is in the turbulent region. With the valve open, the body of the valve is also located in the turbulent region and the valve rod is protected. The valves are not used to control the gas flow; they are only opened or closed all the way.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is explained below on the basis of one embodiment represented in the diagrams. However, FIGS. 1–7 constitute no limitation of the present invention.

FIG. 1 is a schematic survey diagram showing an exploded view of the main components of the device for the sake of better clarity.

FIG. 2 shows an incineration furnace 3 with its most important details and, not shown in detail, a feeding device 4 and a device 5 for the removal of solid reaction products with a waste drum 6 located within a radiation shield.

FIG. 3 shows a feeding device 4, FIG. 4 a device 5 for the removal of solid reaction products from the furnace

3.

FIG. 5 shows a flue gas filter 7 or 8 in operation with a device for replacing filter candles (fixed box) 74 into which the lid 72 of the flue gas filter 7 or 8 is drawn during replacement of the filter candles, and a device 75 for the removal of ashes with the waste drum 6 set up underneath.

FIG. 5*a* represents part of FIG. 5 during replacement of a filter candle; the lid 72 of the flue gas filter 7 or 8 has been drawn into the fixed box 74 and arrested so that the ceramic filter candles 71 can be knocked out of their support plate 70.

FIG. 6 shows a device for replacing filter candles (removable box) 73, which can be used for all flue gas filters 7 or 8 of the same design, during replacement of a filter candle and attached to a flue gas filter (shown only as a fragment). For this purpose, the lid 72 is removed before the removable box 73 is attached. For removal of the spent filter candles 71 the plate 70 is drawn into the box by means of the lifting device 91 and the plate 70 is arrested. Now the filter candles 71 are accessible.

FIG. 7 shows a flue gas valve 101.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to FIG. 1, before startup the device is pre-heated to approximately 400° C by means of electrical air heaters 2. The air heaters are of the conventional type and are supplied room air by means of a forced draught blower 1 of known design. The solid radioactive wastes, normally packed in plastic bags, are introduced into the furnace 3 by means of the feeding device 4. The waste drops into the furnace and is ignited in the bottom section 23 (FIG. 2). The flue gas generated is removed in the upper part of the center section 22 through the flue gas discharge 17, and is fed through the lined flue gas line 9 into a flue gas filter (coarse filter) 7 which had been pre-heated before by means of the by-pass line 11. The flue gas flows from below through the porous ceramic filter candles 71 (FIG. 5) which are open at the top only. All the filter candles taken together constitute a relatively large contact area for afterburning of unburnt or incompletely burnt substances contained in the flue gas which may be generated especially in the combustion of polyethylene and other plastics. The pre-cleaned flue gases leave the coarse filter 7 through the discharge 69 and are run into a similar flue gas filter which is used as a fine filter 8. After fine filtering, the clean gas is mixed with air at room temperature in a mixer section 12, cooled in this way and forced by flue gas blowers 13 past a radiation monitoring device 14 into a stack 15. The mixer section 12 and the flue gas blowers 13 are also conventional designs.

Turning once more to FIG. 2, solid wastes are moved into the interior 33 of the center section 22 through the feed aperture 27 in the top section of the furnace 21, on top of which aperture the feeding device 4 is located. Liquid wastes are continuously injected by a metering pump into the interior 33 through the device 16 in the lid of the furnace 21. The device 16 can be removed from the furnace for protection against scaling or melting. The remaining aperture will then be closed. The incineration process can be supervised through an air cooled sight glass 28 in the lid of the furnace 21. The air inlet 19 is directed at the damper 30 closing the interior 34 of the bottom section 23. The air cools this damper and prevents it from being plugged or from sticking caused by ashes or solid reaction products. It may be observed in FIG. 4 that as the damper 30 is lowered, it frees the entire cross-section of the aperture 29, thus causing solid reaction products and ashes to fall through a device 5 consisting of an intermediate lock 52 and a glove box 51, through a coarse grating 61 into a waste drum 6. The two air inlets 18 and 19 are arranged tangentially and in opposed senses so as to achieve good mixing. The air flows are controlled by means of throttles 18*a* and 19*a* installed in the air inlets. The air inlet 20 with the throttle 20*a* is used only to cool the flue gases, which is achieved by a radial admission of cooling air.

Due to the subdivision of the furnace 3 into three sections 21, 22 and 23, each of which is equipped with flanges, and the design of the center section 22, which is supported on a platform 25 by brackets 24 and whose bottom section 26 penetrates into a separate chamber underneath the platform, the top section 21 and the bottom section 23, which are components subject to wear, can be removed, for instance for purposes of repair. At least the outer layers of the multi-layered refractory ceramic lining 31 rest upon angular brackets 32 made of heat-resistant steel and attached to the bottom end of the frame of the center section 22. After separation of the ceramic lining 31, which is closed on the inside, the bottom section 23 can be disengaged from the bottom part 26 of the center section 22. After reattachment of the bottom section 23, the refractory lining 31 must be repaired and closed.

The feeding device 4 represented in FIG. 3 is connected with the feeding aperture 27 in the lid of the furnace 21 by means of its bottom discharge opening 38. The feeding device 4 essentially consists of a steel vessel 35 lined with an insulating material 36, and a specially designed slide damper 37. The slide damper consists of a ceramic feeder plate 37*a* with an aperture 43 the dimensions of which correspond to those of the bottom discharge 38, a bottomless pot or hood 44 which is arranged above the aperture 43, and into which the solid wastes are introduced through the waste feed aperture 39, an angular section 45 connecting the pot 44 and the ceramic plate 37*a* which a push rod 46 attached to this angular section which is moved by means of a compressed air cylinder 47. For feeding wastes into the feeding device 4, the slide damper 37 is pushed in. In this position the plate 37*a* closes the bottom discharge 38 and a steel shielding plate 49 rigidly connected with the wall of the vessel 50 separates the operature 43 of the ceramic plate 37*a* from the pot 44, thus avoiding that wastes stick to the bottom of the vessel 48. If the pot 44 is filled with waste, the aperture 39 is closed with a lid 40, and the slide damper 37 is pulled outward until the opening 43 arrives in registry with the bottom discharge 38 and the waste drop into the furnace 3. The aperture 41 closed with a lid 42 is used for cleaning of the furnace 3 and for slag removal. Since the vessel 35 is closed while the furnace is loaded, except for the discharge 38, no radioactively contaminated flue gases can escape.

As is shown in FIG. 4, the device 5 for the removal of solid reaction products from the furnace 3 consists of an inermediate lock 52 flanged onto the bottom end of the furnace and a glove box 51 attached to it. For the removal of solid reaction products the damper 30 is moved downward into the intermediate lock 52, which intermediate lock mainly consists of a vessel 53 with

several sockets **54** which can be closed with lids **55.** At the same time, the damper **59** consisting of two parts, which closes the glove box **51** at the top, is moved in front of the two windows **58** for protection. The reaction products and the ashes drop into the waste drum **6** through the opening **60** equipped with a coarse grating **61.** For crushing large pieces of slag which will not pass through the grating **61** the glove box **51** is equipped with glove ports **56** which can be closed with plugs **57** from the inside. Moreover, the box **51** is equipped with a large area explosion damper **64,** a flushing connection **62,** and a tool lock **63.**

The flue gas filter **7** or **8** shown in FIG. **5** comprises a steel frame **65** with a ceramic lining **66.** The flue gases emanating from the furnace **3** or from the coarse filter **7** enter the filter through the flue gas inlet **68,** flow through the surge chamber **76** and afterwards pass through the porous filter candles **71** (closed at their bottom ends **77**) from the outside to the inside and are removed through the discharge opening **69.** The ashes generated in afterburning at the filter candles **71** are dropped into the ash removing device (box for filter ashes) **75** through the aperture **67** for the removal of ashes after opening the movable closing damper **83** and are passed through a coarse grating **84** and dropped into a waste drum **6.** The filter candles are suspended in a steel or ceramic plate **70** resting on the lining **66.** The flue gases are withdrawn above the plate. The preheating gas required before startup of the filter either flows into the filter through the flue gas inlet **68** and out through the opening **78** or, for instance prior to changing over to a parallel filter, enters the filter through the opening **78** and leaves it through the discharge **69.** The filter is protected against sudden conflagration by an explosion damper **79** of the same type as that installed in the flue gas line **9** and designated with the reference number **10.** The box **75** for filter ashes contains several glove ports **80,** at least one window **82,** at least one tool lock **81** to crush on the grate **61** the fragments of spent filter candles **71** during the replacement of filter candles.

The device **74** for replacing filter candles is shown in FIGS. **5** and *5a.* This is a fixed box, i.e., a glove box fixed to the steel frame **65** of the flue gas filter **7** or **8** which remains on that filter even while the latter is in operation, i.e., it should not be used for the replacement of filter candles of several filters. It is so designed that the lid **72** of the filter **7** or **8** can be pulled into the box up to or above the window or windows **98** by means of the pull rod **99** connected with the lid **72** and penetrating gastight through the wall of the fixed box **74.** The fixed box **74** is equipped with an arresting device **100** retaining the lid **72** in the lifted position. Afterwards, the filter candles **71** can be replaced through the glove box apertures **96** and the tool lock **97,** respectively.

In FIG. **6,** a different design of a replacement device **73** for filter candles is shown which is attached to the filter after removal of the lid **72** of a filter **7** or **8.** This device **73,** which is a removable box, is attached to several filters for replacement of the filter candles. It consists of an upper part **86** and a lower part **85** into which the plate **70** with the filter candles **71** is drawn for the replacement of filter candles by means of a lifting device **91** penetrating gastight through the housing **87** of the removable box **73** and locked by means of a locking device **90.** The lifting device **91** consists essentially of a pull rod **95** and a grip **93** engaging into hooks **94** attached to the plate **70.** The upper part **86** of the removable box **73** tapers conically towards the top and is equipped with at least one window **92.** Filter candles **71** are replaced through the glove box apertures **88** and the tool lock(s) **89,** respectively, in the lower part **85** of the removable box **73.**

FIG. **7** shows a design of a flue gas valve **101** designed as an angle valve also equipped with a multi-layer refractory lining **103,** like the flue gas line **9** which is designated with the reference number **102** in FIG. **2.** The angle valve **101** comprises of a T-shaped valve housing **104** made of steel plate and a valve body **106** machined spherically out of round steel and pivoted to a valve rod **105.** In the closed position the valve is sealed by the valve body **106** which engages the annular valve seat **107** made of heat resistant steel arranged inwardly of the lining **103.**

What we claim is:

1. An apparatus for incinerating radioactive wastes and preparing combustible radioactive wastes for non-polluting storage, comprising in combination:

a. a grateless furnace being formed of vertically adjoining top, center and bottom sections each defining an inner space, said furnace having a charging end in said top section and a discharge end in said bottom section;

b. a movable damper means positioned in said bottom section for closing said discharge end during incineration;

c. a first air inlet conduit communicating with the inner space defined by said center section;

d. a second air inlet conduit merging tangentially with the inner space defined by said bottom section, in the zone of said discharge end; said second air inlet conduit being oriented towards said damper means in a direction opposite to the orientation of said first air inlet conduit;

e. means disposed externally of said furnace for dividing the space surrounding said furnace into an upper external space surrounding said top and center sections and into a lower external space surrounding said bottom section;

f. a flue gas outlet conduit communicating with the inner space defined by center section;

g. a removable solid waste feeding device communicating with said charging end and being supported by said top section;

h. a liquid waste feeding device communicating with said charging end and being supported by said top section;

i. a flue gas filter having an input connected to said flue gas outlet conduit; filter candles; means for replacing the filter candles; a flue gas surge chamber; means for removing ashes from the flue gas surge chamber; and an outlet; and

j. a removable glove box attached to said discharge end of said furnace; said glove box having an inlet provided with a two-part gate for controlling the outflow of solid material from said furnace and an outlet provided with a coarse grate.

2. An apparatus as defined in claim **1,** wherein said flue gas filter has a square shape tapering down towards the bottom to an aperture for the removal of ashes.

3. An apparatus as defined in claim **1,** wherein said liquid waste feeding device includes a double tube formed of an inner tube for feeding the burnable liquid into the furnace and an outer tube for admitting compressed air to dissipate the liquid and cool the inner

tube.

4. An apparatus as defined in claim 1, the inner space defined by said center section having a cylindrical configuration, the inner space defined by said bottom section having an upper chamber portion of downwardly tapering conical shape, the diameter of a lower terminus of said upper chamber portion being one third the diameter of an upper terminus of said upper chamber portion; the inner space defined by said bottom section further having a lower chamber portion of uniform cylindrical shape, said lower chamber portion adjoining said upper chamber portion and extending downwardly therefrom.

5. An apparatus as defined in claim 1, said solid waste feeding device including a vessel having a floor; means defining an opening in said vessel floor for communicating with said charging end of said furnace; a slide damper movably supported in said vessel and cooperating with said opening to control the discharge of solid wastes from said vessel into said furnace; and means defining a further opening in said vessel for introducing solid wastes thereinto.

6. An apparatus as defined in claim 5, said slide damper including a feeder plate movable along the vessel floor, means defining an aperture in said plate, said aperture having substantially the same dimensions as said opening in said vessel floor; an upright, laterally closed, open-ended, upwardly slightly tapered hood disposed above said aperture and affixed to said feeder plate; an actuating rod affixed at least indirectly to said feeder plate and projecting outwardly from said vessel; and power cylinder means operatively connected to said actuating rod.

7. An apparatus as defined in claim 6, further including a shielding plate affixed to said vessel and extending parallelspaced from said vessel floor adjacent said opening; said shielding plate extending between said hood and said feeder plate above said aperture in said feeder plate when said feeder plate covers said opening in said vessel floor.

8. An apparatus as defined in claim 7, wherein said feeder plate is made of ceramic and said shielding plate is made of metal.

9. An apparatus as defined in claim 1, said glove box further having two oppositely arranged observation windows; said two-part gate being pivotally supported and covering said observation windows when in a position in which it frees the inlet of said glove box.

10. An apparatus as defined in claim 1, said filter candles having upper ends connected to said means for replacing the filter candles; said filter candles having lower ends detachably connected with said means for removing ashes from the flue gas surge chamber.

11. An apparatus as defined in claim 1, wherein said gas filter includes means defining a cylindrical chamber below said filter candles, said cylindrical chamber constituting said flue gas surge chamber.

12. An apparatus as defined in claim 1, wherein said gas filter includes means defining a square chamber below said filter candles, said square chamber constituting said flue gas surge chamber.

13. An apparatus as defined in claim 1, wherein said means for removing ashes from the flue gas surge chamber is constituted by a glove box attached to the outlet of said gas filter.

14. An apparatus as defined in claim 13, said glove box attached to the outlet of said gas filter having several glove ports, at least one tool lock, at least one window, a movable damper closing and clearing the outlet of said gas filter for the removal of ashes from the flue gas filter and a coarse grate disposed at the lower end of said glove box attached to the outlet of said gas filter.

15. An apparatus as defined in claim 1, said means for replacing the filter candles in the flue gas filter including

a. a filter candle support plate from which said filter candles are suspended;
b. a removable box attached to an upper part of the gas filter;
c. lifting means supported by said box for vertically moving said filter candle support plate;
d. at least one tool lock provided in said box; and
e. an arresting device affixed to said box for locking said filter candle support plate in a lifted position within said box.

16. An apparatus as define in claim 1, wherein said gas filter includes a frame and a vertically movable lid; said means for replacing the filter candles includes a fixed glove box disposed about said lid and permanently affixed to said frame.

17. An apparatus as defined in claim 16, wherein said fixed box has a sufficient inner width to allow the lid to be moved up and down therein, several glove ports, at least one tool lock, at least one window and a push rod connected with the lid and penetrating the wall of the fixed box in a gastight manner, an arresting device for locking the lid when pulled up beyond the level of the window for the replacement of filter candles.

18. An apparatus as defined in claim 1, said center section including a multilayer refractory ceramic lining; further comprising angular brackets supported on said bottom section; at least the outer layers of said lining being supported upright by said angular brackets.

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